

Advanced Field Single Plane Trim Balancing

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Summary

- **Problem Statement**

Trim Balancing of multiple units may imply schedule impact.

- **Solution**

Develop a single-shot procedure to embed balancing activity in the general commissioning.

- **Results**

Flawless start-up of 5 Large LNG strings with multiple units as of November 2010.

- **Lesson Learned**

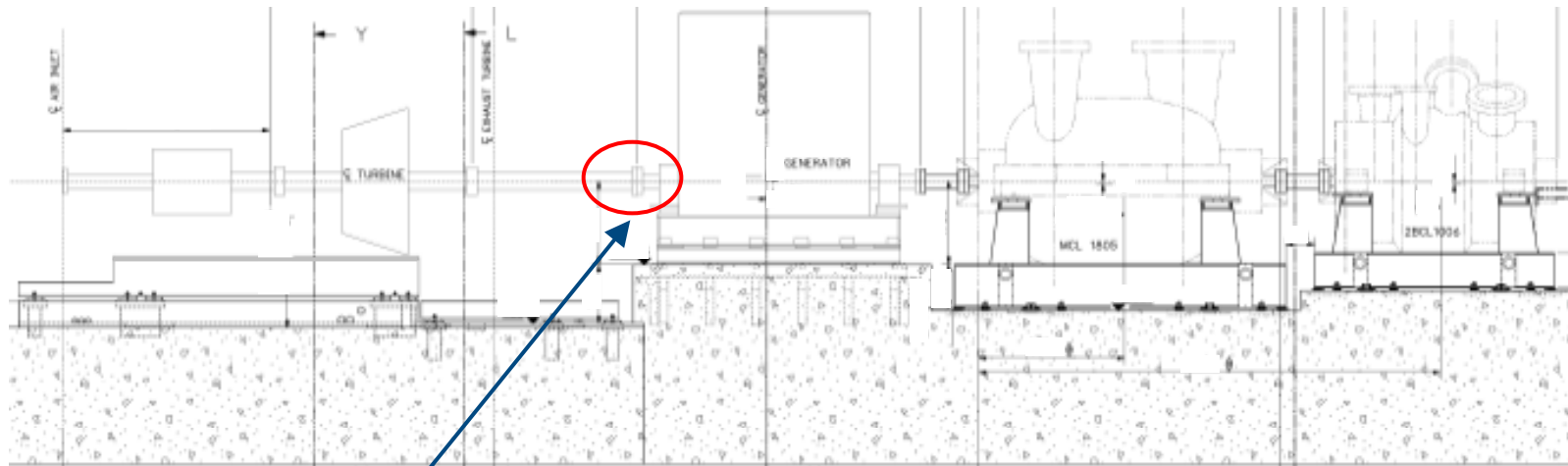
Procedure development during Full-Load Factory String Test.

Problem Statement

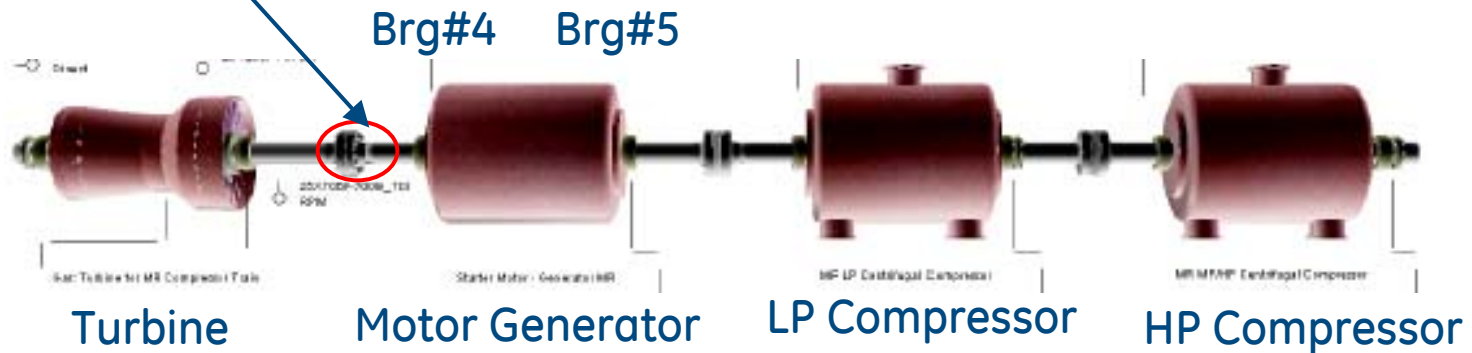
Problem Statement

Shaft vibration in the region of alarm during commissioning, when units are tested in different configurations, may be considered not advisable and its resolution may imply schedule delays, if not properly addressed.

Problem Statement



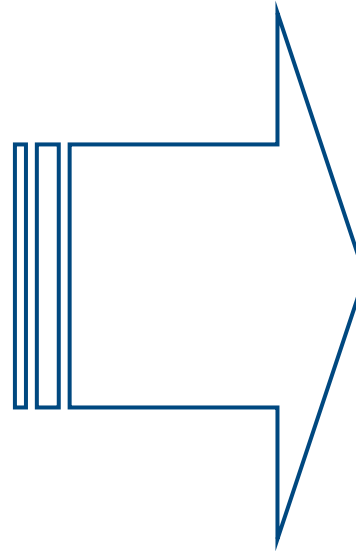
Trim Balancing Plane



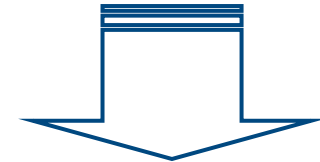
Traditional Solution has a Drawback

FACTS

- Mainly 1X vibration on BRG#4.
- Individual balancing of GT, motor and other shaft line components during factory tests well within acceptance criteria.
- No abnormal behaviour of other parameters (bearing and oil temperature, etc).
- No sign of misalignment (i.e. Abnormal 2x vibrations).
- Trim balancing on a plane close to high vibration point proved effective in the past.



Trim Balancing on
outboard coupling
flange



Unfortunately,
traditional trim
balance needs 3
trials

Traditional Trim Balancing Procedure

Step 0: Measure initial unbalance (vector V_0)

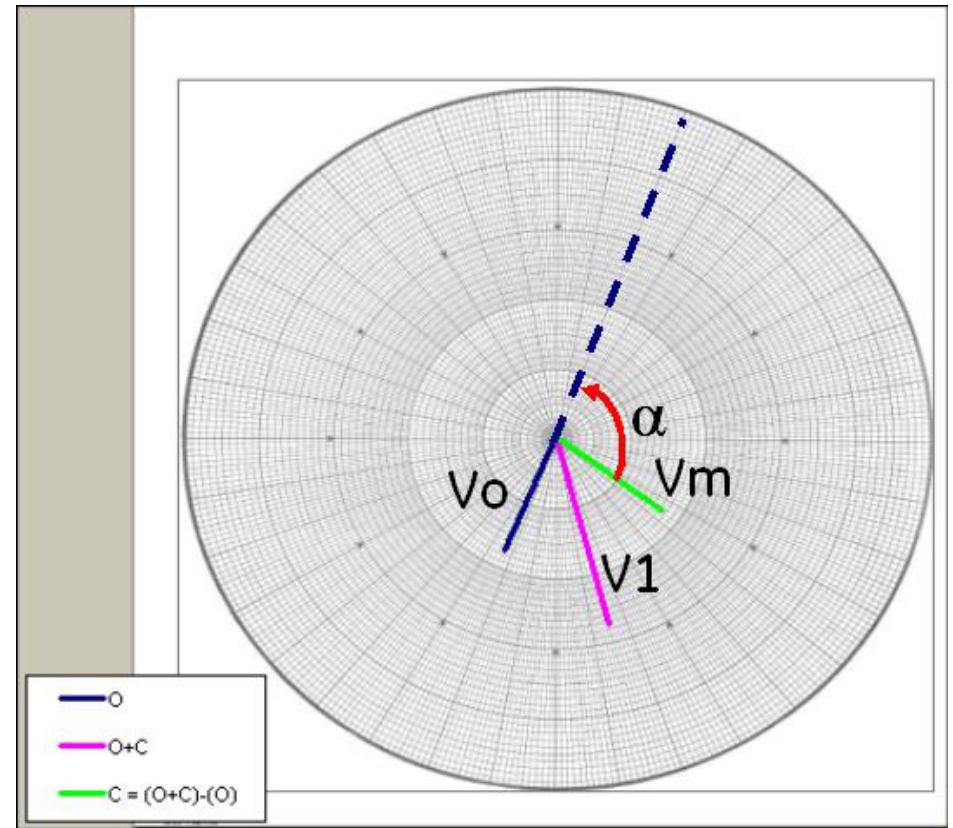
Step 1 Start-up the machine with a trial mass and measure new unbalance after the unit is stabilized (Vector V_1)

Step 2: Calculate effect of trial mass (V_m , difference between V_1 and V_0)

Step 3: Stop unit, move balancing mass by angle α and correct weight by V_0/V_m .

Step 4: Restart the unit and measure effect of new balancing mass after stabilization

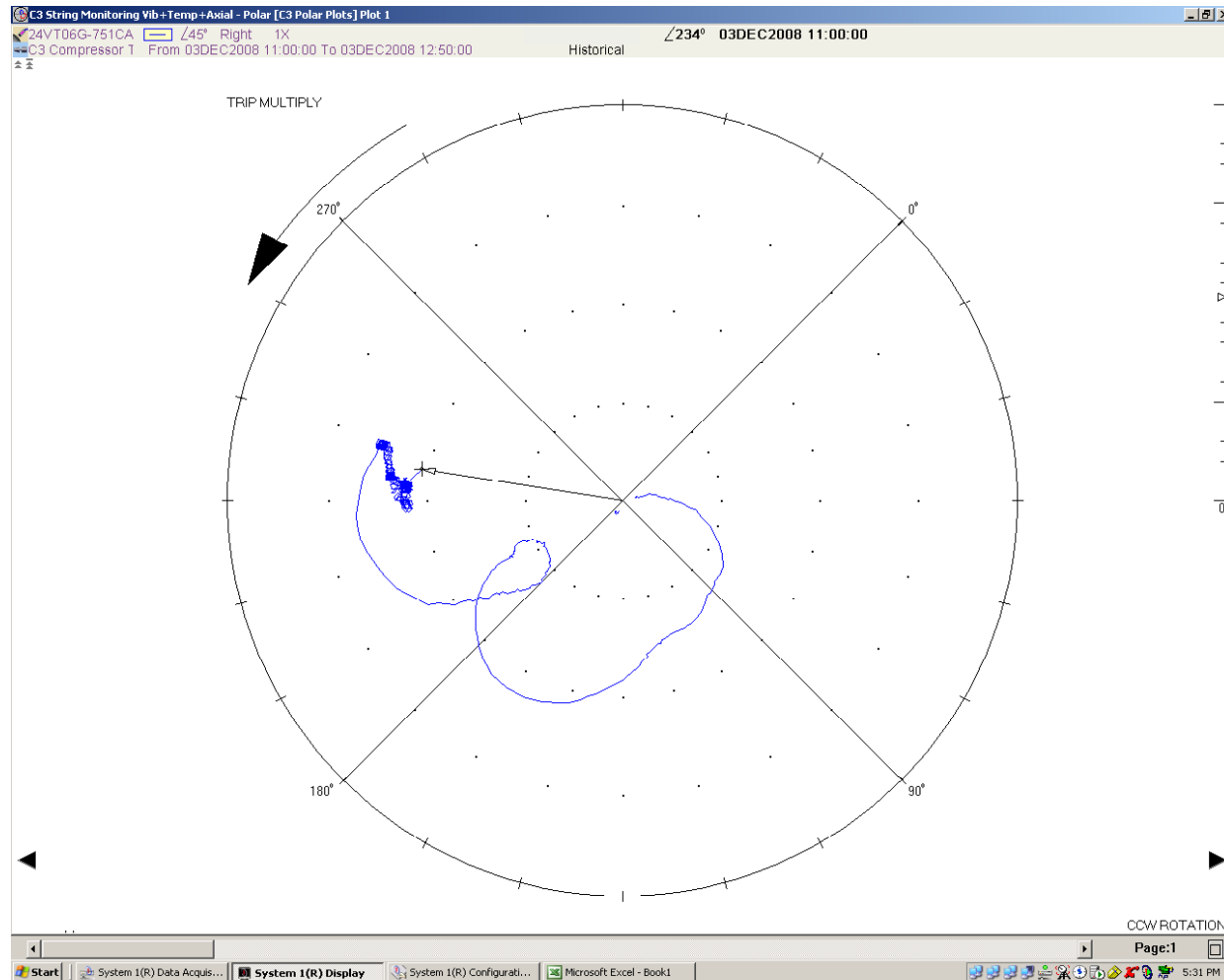
Step 5: Repeat step 2 and, if necessary, repeat step 3 and 4 for fine tuning.



Typically, 2 to 3 starts are required for a trim balancing starting from scratch

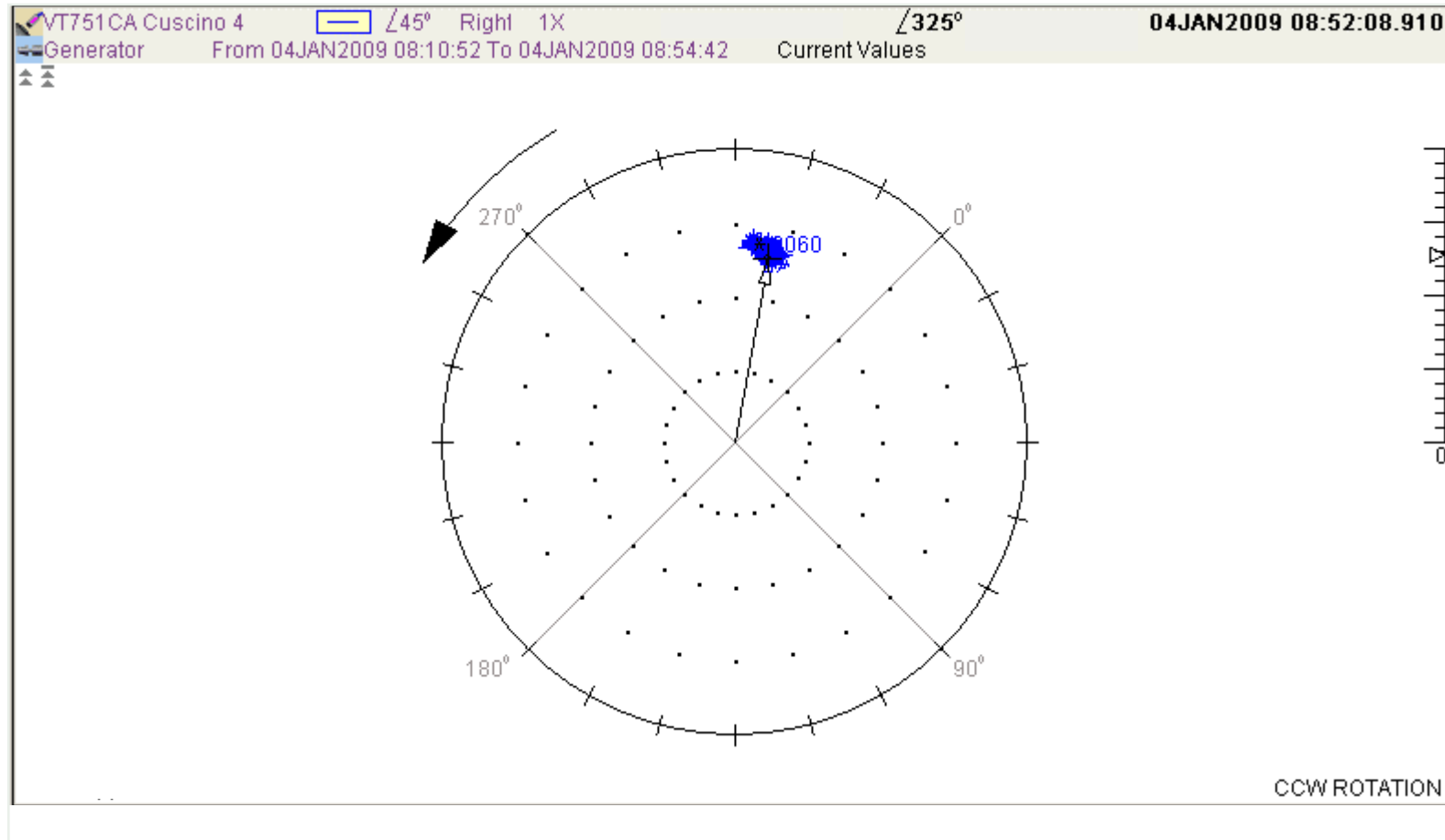
Initial Condition on First Unit – BRG #4

Residual unbalance vector at 100% speed



The optimization of the vibration was considered advisable since the machines were in new condition.

Final Condition on First Unit – BRG #4



- Trim balance was highly effective with a reduced balancing mass (just 240 grams), however it required 3 additional start-ups, even if not an issue in the specific situation.

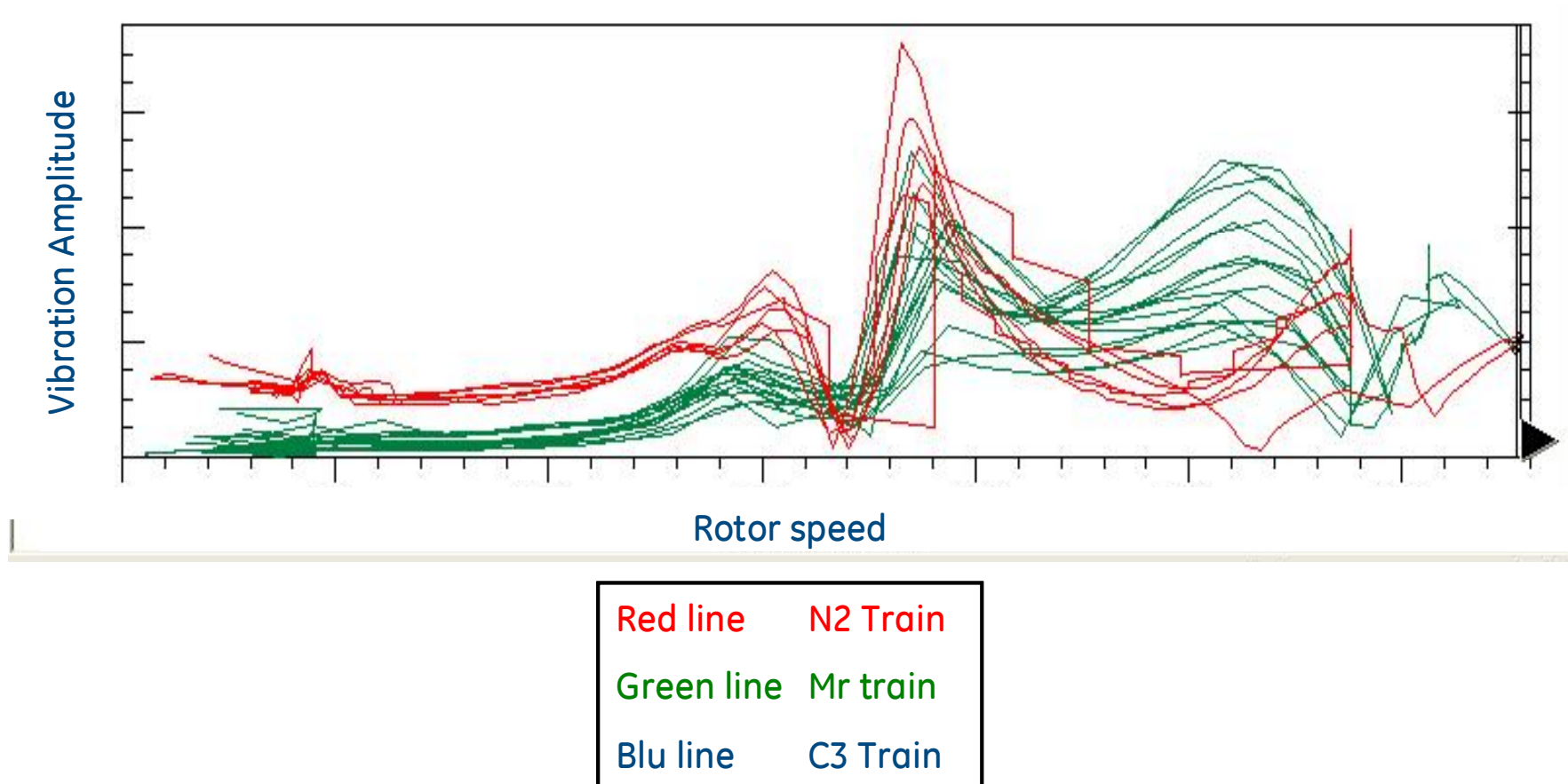
Challenge

Is it possible to develop a repeatable Trim Balancing Procedure for similar units, such that the number of required starts is minimized and ideally reduced to one single shot?

This is specially important when the units are embedded in a large process, such as an LNG plant, and the schedule is tight.

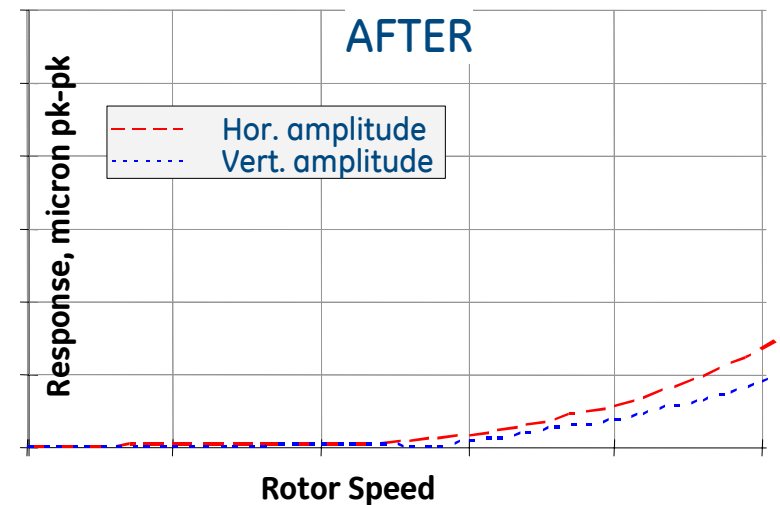
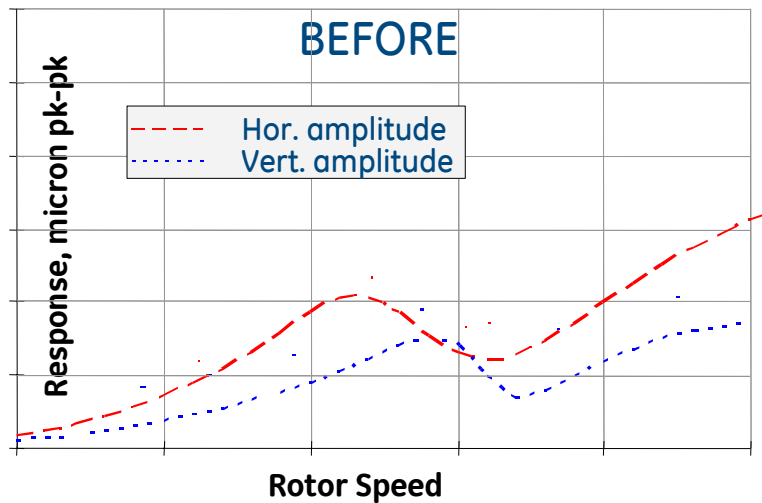
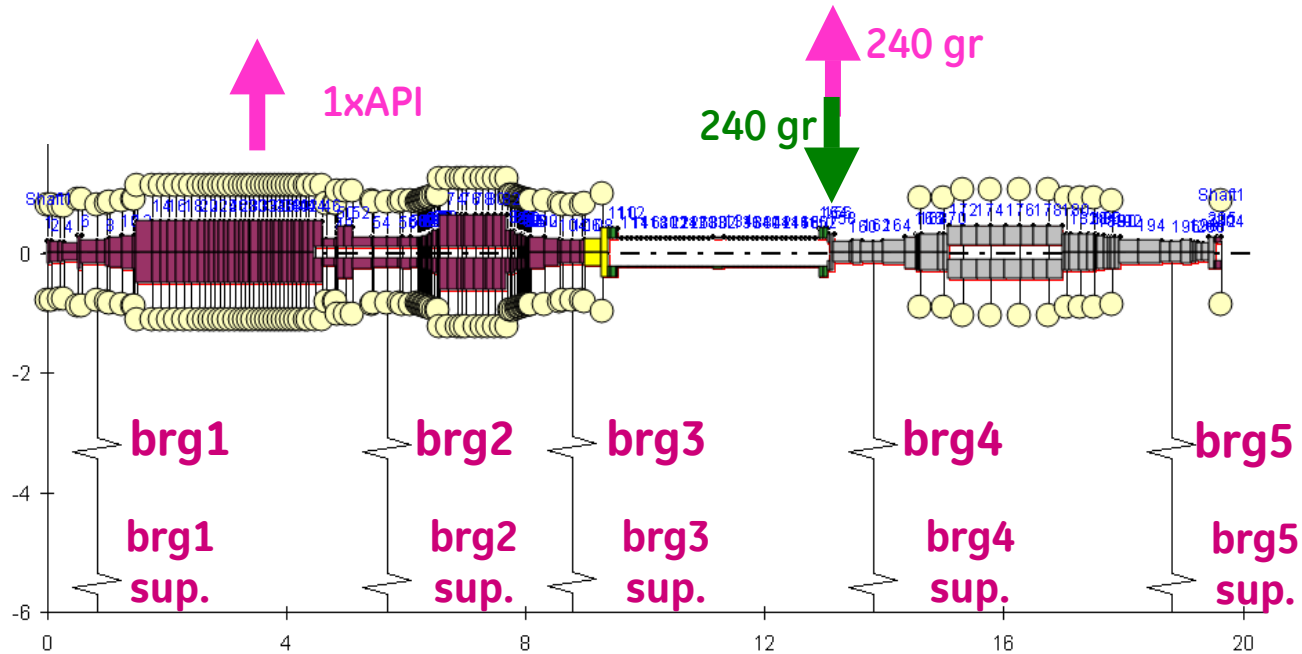
Solution

Comparison of trends before Trim Balance



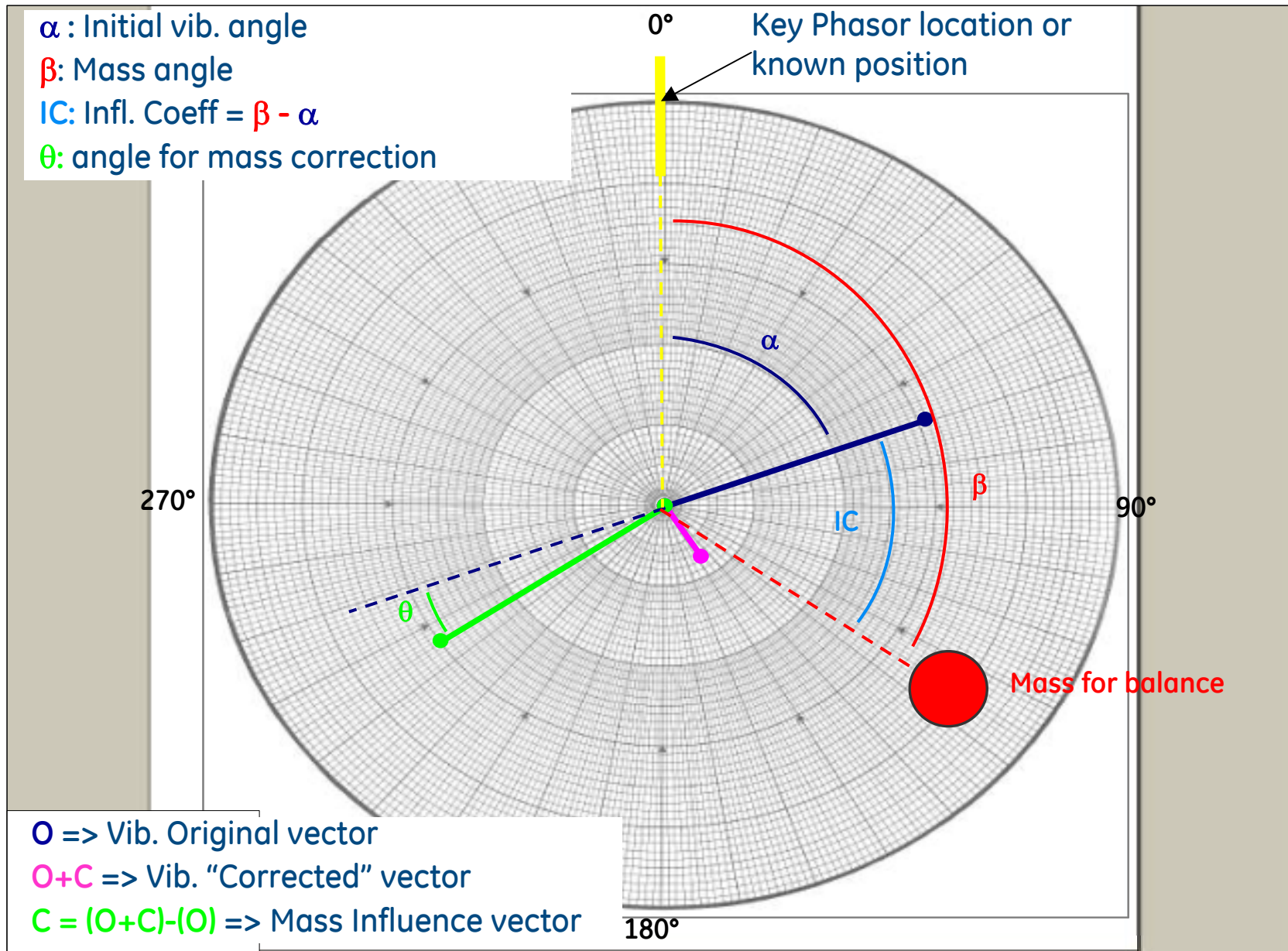
Similar strings show similar behavior

Trim Balance Simulation



Simulation of unbalance first and of trim balance afterwards confirms repeatability

Single-shot Trim balance Influence Coefficient



Single-shot Trim balance Influence Coefficient

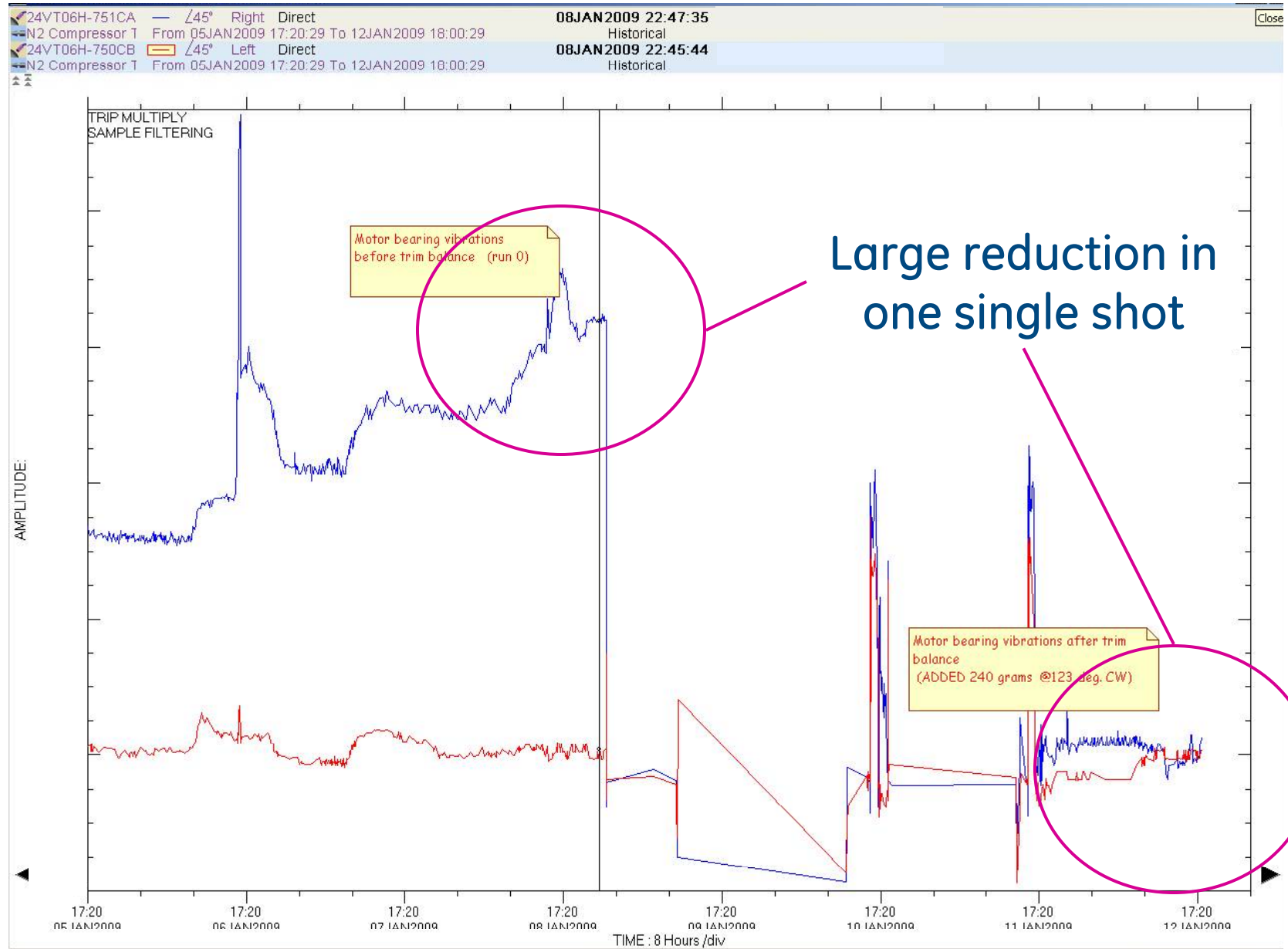
- The influence coefficient is defined as the angular difference between the original vibration vector angle (α) and the position of the balancing mass (β), as determined on the first unit after the final (3rd) shot.
- Calculated Influence coefficient was $\sim 75^\circ$
- Typical balancing mass ~ 240 g at 343 mm radius, as determined on the first unit after the final (3rd) shot.



Balancing weight used for trim balance (off-the-shelf windage plug to be installed on flange stud bolts)

Results

One-shot trim balance result on next units (typical)



Conclusions and lessons learned

- Trim Balancing from scratch typically requires 2 to 3 attempts... likely not affordable in a tight schedule when each attempt may imply partial start-up and shut-down of the downstream plant and some time to stabilize the running units
- Similar units when analyzed show similar behavior...theoretical simulation confirms repeatability and position of balancing mass....A common influence coefficient can be developed to obtain a single-shot trim balance.
- **Flawless start-up of 5 large LNG plants with multiple units...**The new procedure allowed execution of trim balance, when required, with no impact whatsoever in the general commissioning program and using one of the already planned shutdowns.
- When deemed necessary, a single-shot trim balancing procedure should be developed during full-load factory string tests and become part of the general commissioning procedure